Avian Abundance Estimation for Full Life-cycle Conservation Planning

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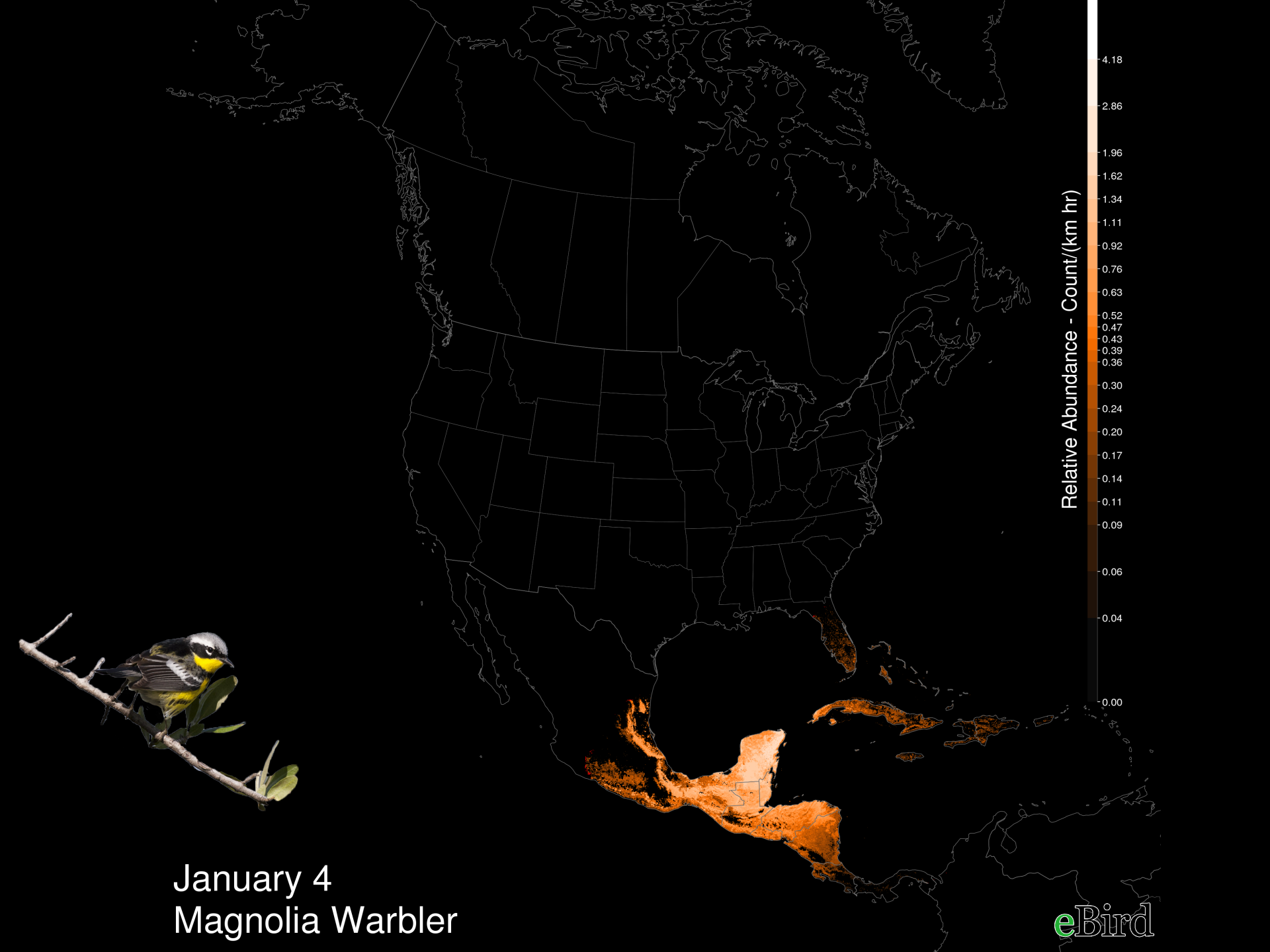
Tom Auer, Nick Bruns, Ali Johnston,
Frank LaSorte, Ben Zuckerberg

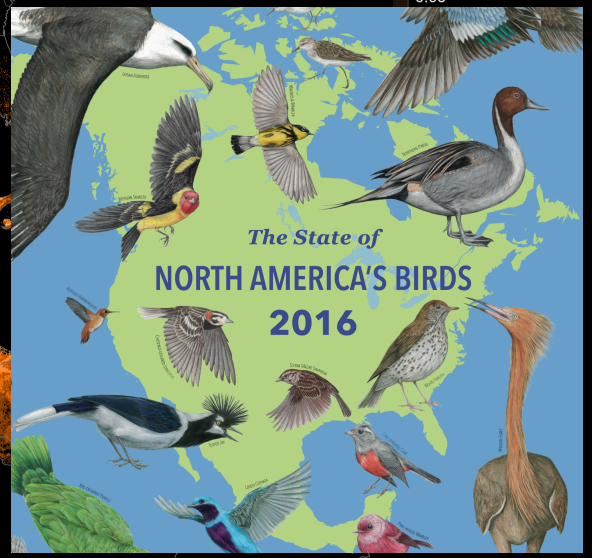
The Cornell Lab of Ornithology

LEON LEVY FOUNDATION
The Legacy Of Leon Levy

Microsoft Azure


Relative Abundance - Count/(km hr)
4.18
2.86
1.96
1.62
1.34
1.11
0.92
0.76
0.63
0.52
0.47
0.43
0.39
0.36
0.30
0.24
0.20
0.17
0.14
0.11
0.09
0.06
0.04
0.00
January 4
Magnolia Warbler
eBird

- Abundance
- North America
- 3km x 3km
- Weekly
- Uncertainty & QA



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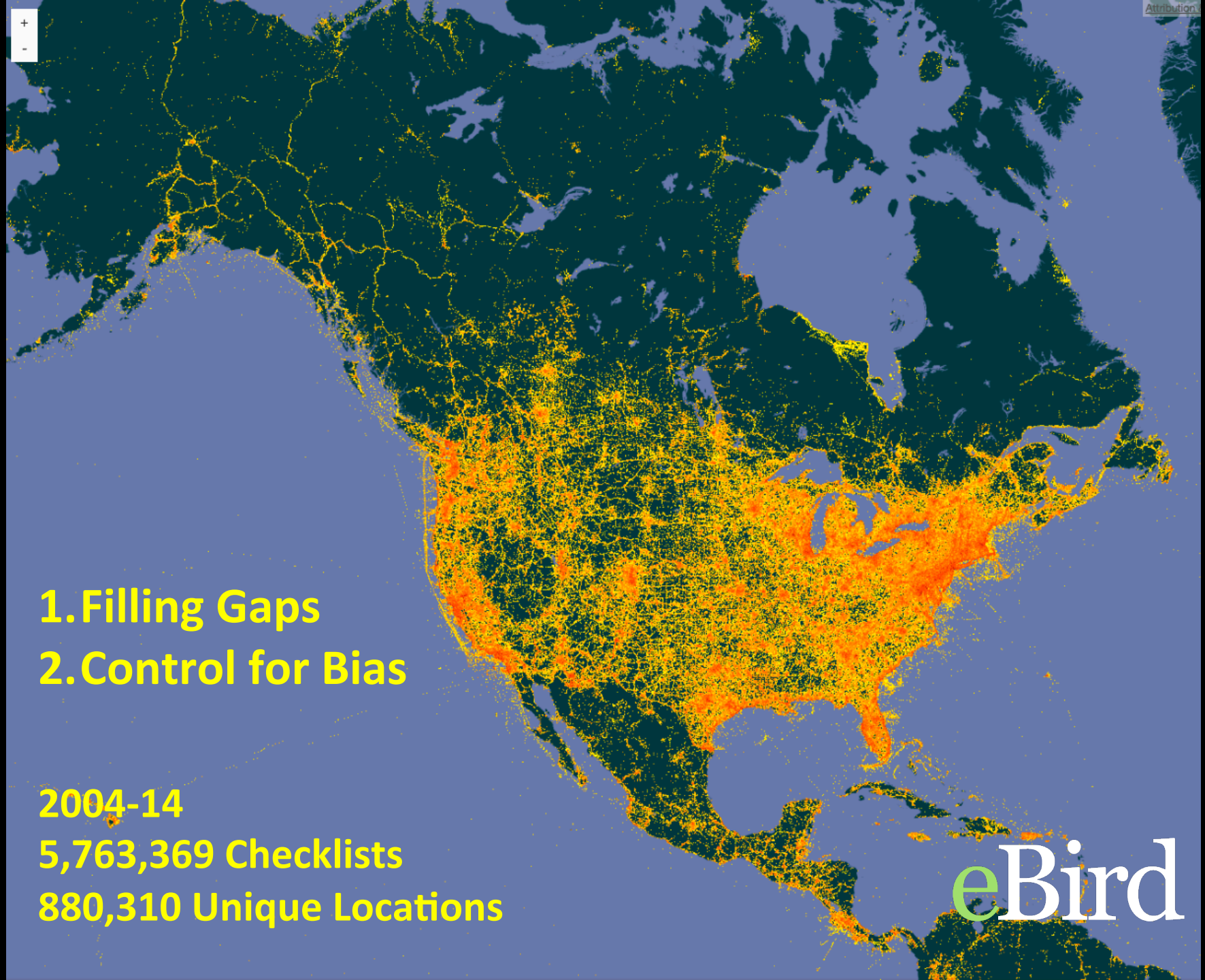

1. Filling Gaps
2. Control for Bias
2004-14
5,763,369 Checklists
880,310 Unique Locations
eBird

- **Observed Count**
- Lat - Lon
- Year (2004-14)
- Day of the Year (1-365)

- Observation Effort
- Observation Time
- Number of Observers
- Stationary/Traveling Protocol

MODIS Landcover
- *2004-12*
- 13 UMD Classes
- % 3km x 3km pixel

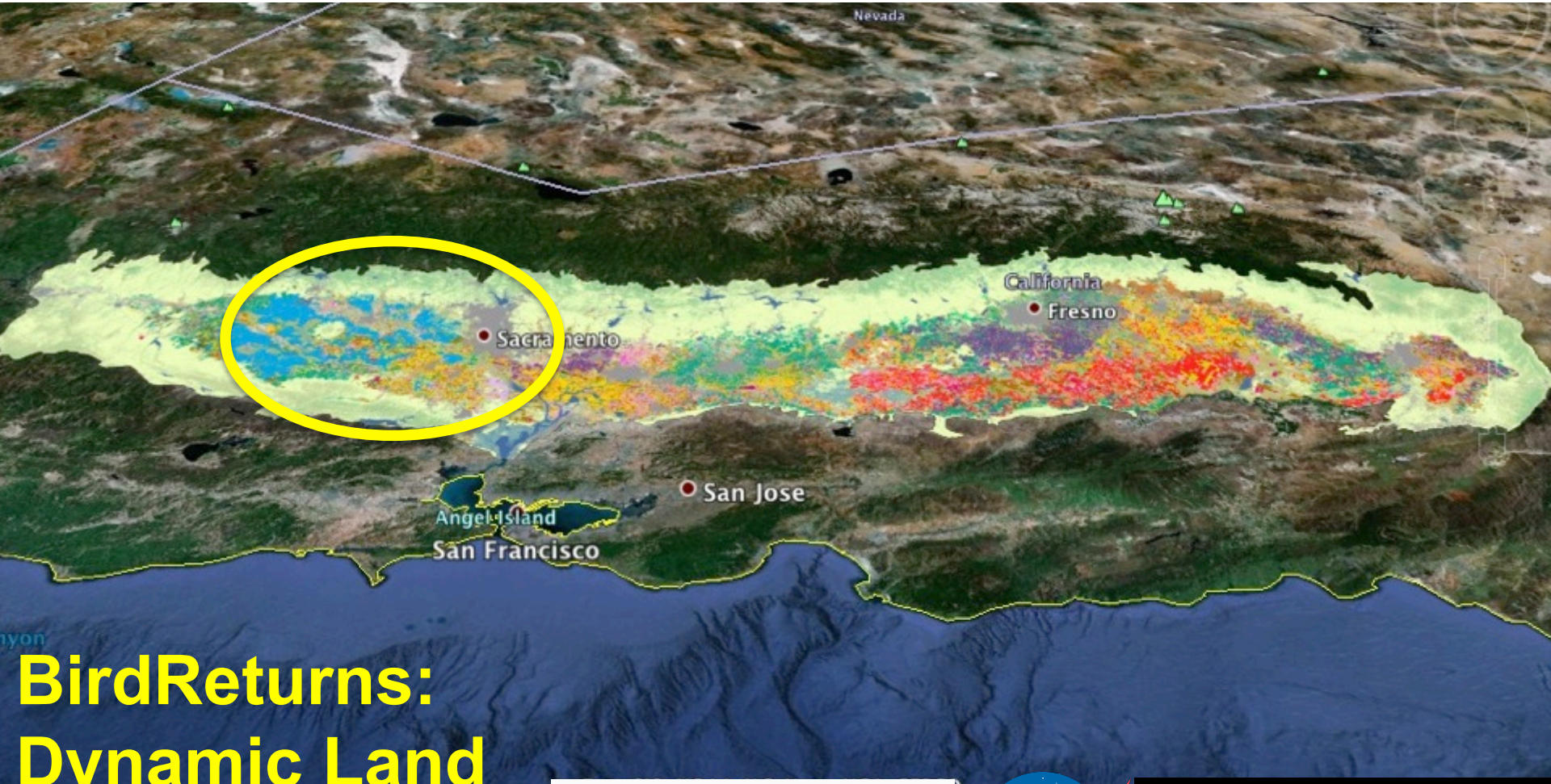
ASTER Elevation

MODIS Land-H2O mask

LandSat Cropland Data
(BirdReturns)

LandSat NLCD
(Habitat Use)

	Water	Evergreen_Needleleaf	Evergreen_Broadleaf	Deciduous_Needleleaf	Deciduous_Broadleaf	Mixed_Forest	Woodland	Wooden_Grassland	Closed_Shrubland	Open_Shrubland	Grassland	Cropland	Urban_Built	Bare
1	77.1930	1.7544	1.7544	0.0000	1.7544	1.7544	0.0000	0.0000	3.5088	3.5088	3.5088	1.7544	1.7544	1.7544
2	42.2222	4.4444	13.3333	0.0000	0.0000	33.3333	0.0000	0.0000	2.2222	2.2222	0.0000	2.2222	0.0000	0.0000
3	22.5000	0.0000	12.5000	0.0000	0.0000	20.0000	2.5000	22.5000	10.0000	0.0000	0.0000	10.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.7778	8.3333	0.0000	88.8889	0.0000	0.0000	0.0000
5	72.5490	11.7647	1.9608	0.0000	0.0000	9.8039	0.0000	0.0000	0.0000	0.0000	0.0000	3.9216	0.0000	0.0000
6	72.5490	11.7647	1.9608	0.0000	0.0000	9.8039	0.0000	0.0000	0.0000	0.0000	0.0000	3.9216	0.0000	0.0000
7	72.5490	11.7647	1.9608	0.0000	0.0000	9.8039	0.0000	0.0000	0.0000	0.0000	0.0000	3.9216	0.0000	0.0000
8	72.5490	11.7647	1.9608	0.0000	0.0000	9.8039	0.0000	0.0000	0.0000	0.0000	0.0000	3.9216	0.0000	0.0000



BirdReturns: Dynamic Land Conservation

The Nature Conservancy

NASA

The Cornell Lab of Ornithology

Modeling Seasonal Abundance

Goals

- Complex abundance – habitat relationships
- Good predictive performance
- Highly automated for diverse species

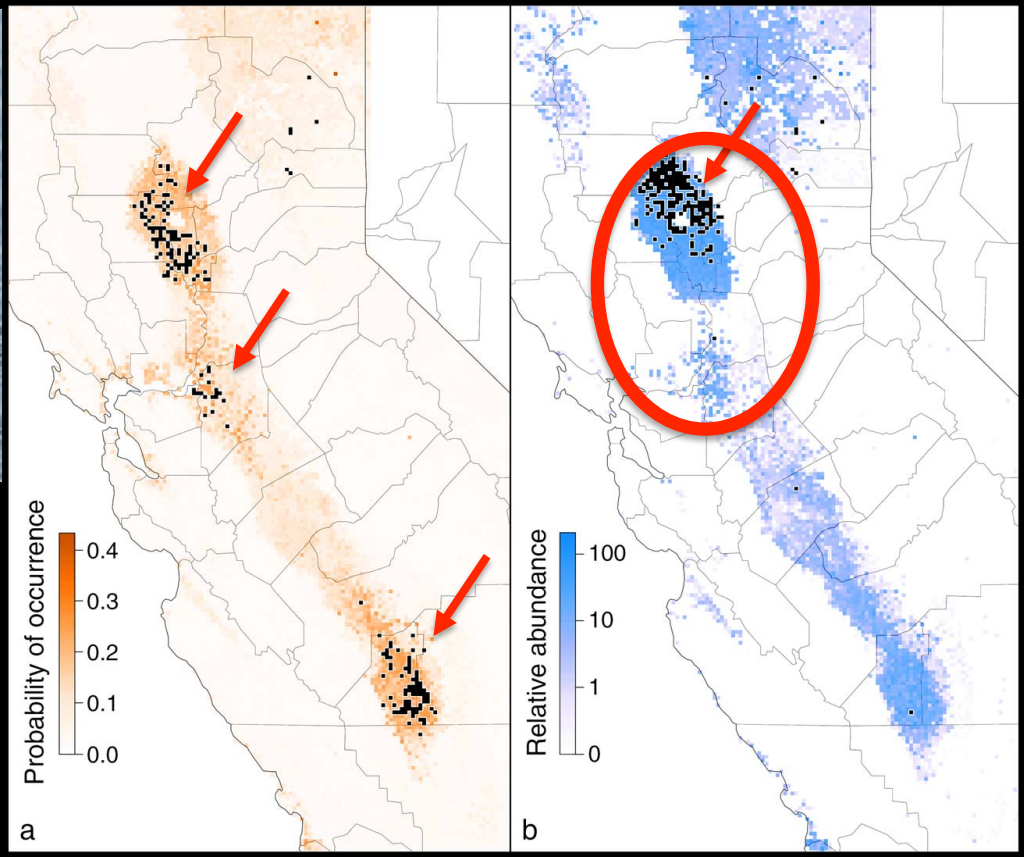
Approach

- Zero-Inflated Boosted Regression Trees (ZI-BRTs)
  1. Estimate suitable habitat
  2. In suitable habitat, estimate abundance
- Resampling-based Ensemble of ZI-BRTs

Johnston et al. (2015), Abundance models improve spatial and temporal prioritization of conservation resources. Ecological Applications, 25: 1749–1756. doi:10.1890/14-1826.1

Northern Pintail

Aerial Survey Data
1987–2000
Fleskes et al. 2007



71–95% Pintails in
Sacramento River Valley

Scaling to Continental Scales

ST Variation in habitat use

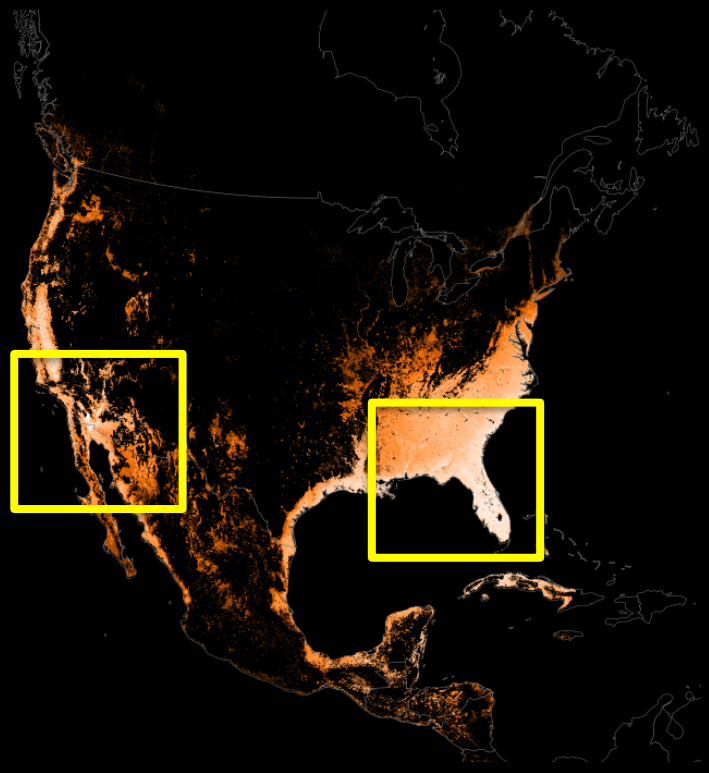
- *Ensemble* of independent, uniformly distributed *regional* models
- 10 deg x 10 deg x 40 days

Data Density & Rarity

- Geographic balanced sampling
- Case-control sampling

Computational strategy

- MapReduce Hadoop

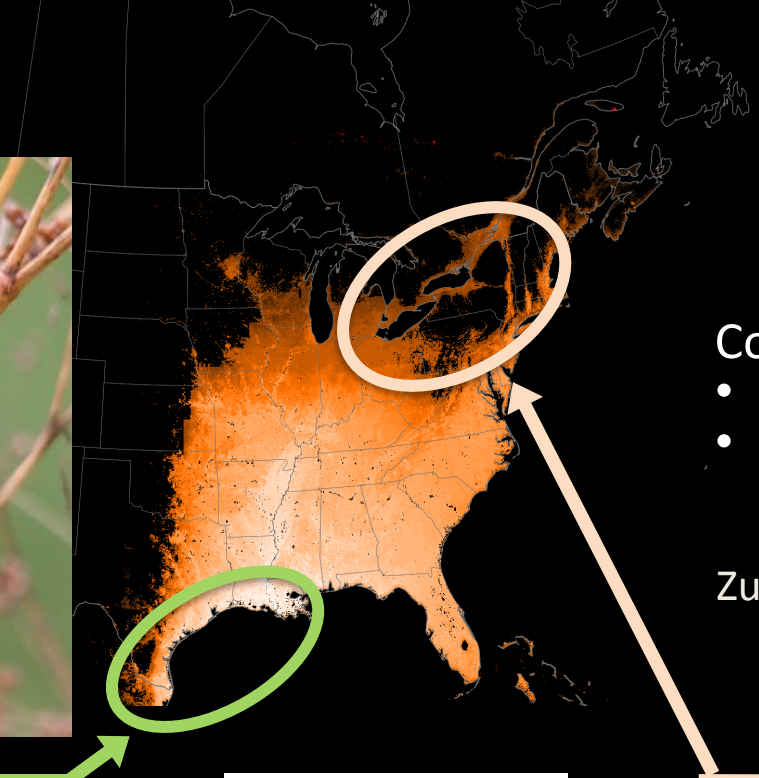


hadoop

HDInsight

Microsoft Azure

Indigo Bunting

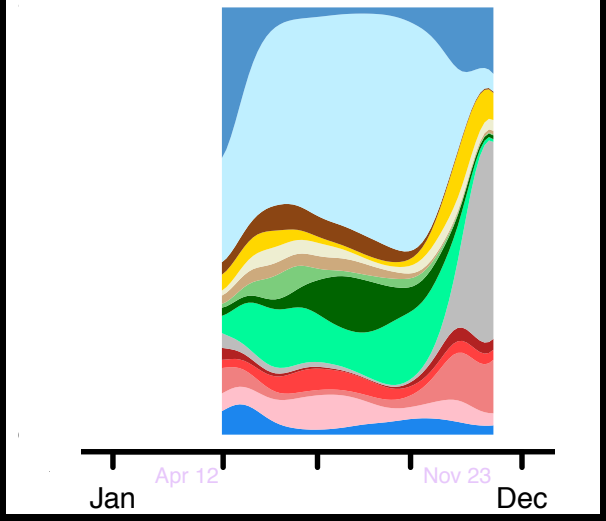


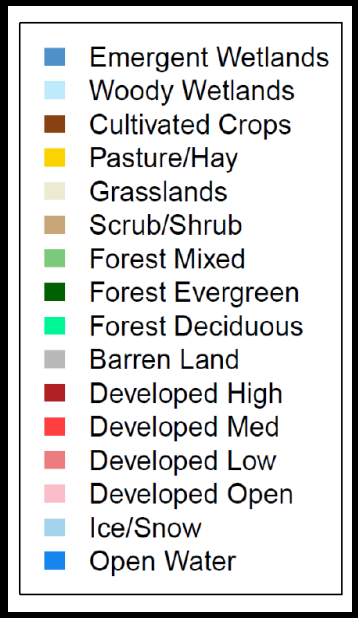
Control for:

- Habitat Availability
- ST variation in search effort

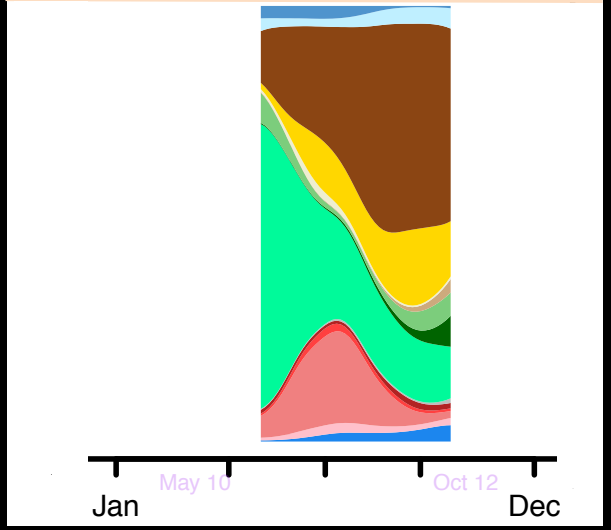
Zuckerberg et al. 2016 Diversity & Distributions

Gulf Coast Prairie





St.Lawrence Plain



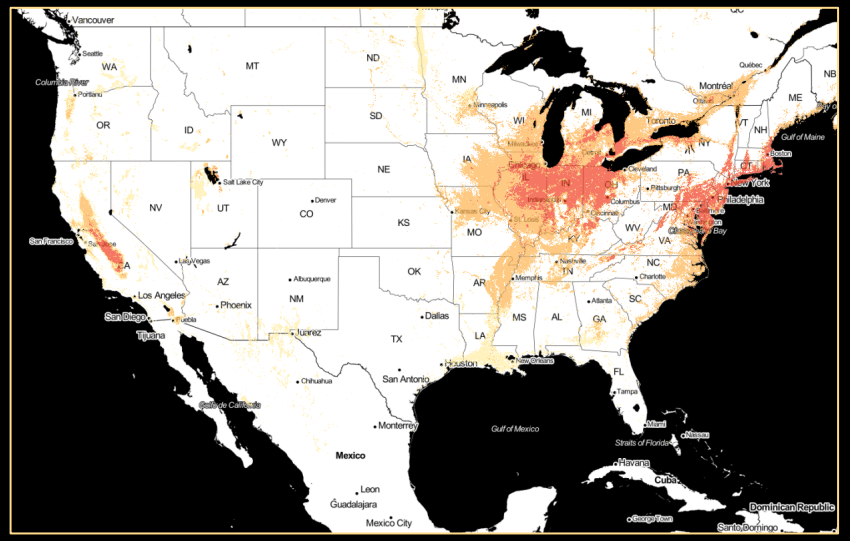
Data Quality: Uncertainty & Validation

Pixel-level Uncertainty

>50% E(count) > 2.5

>90% E(count) > 2.5

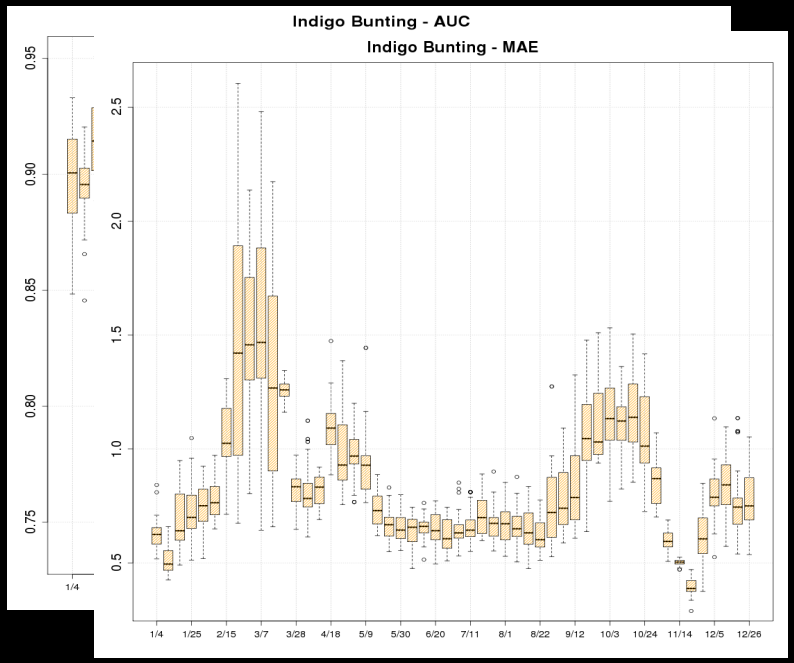
Aggregation: Space, Time, Species



Validation

- Spatially balanced
- Occurrence: AUC, Kappa, PCC, Sensitivity, Specificity
- Abundance: MAE, CV, Deviance

Aggregation: Regions, Seasons, Species



Conclusions

Data for cross-scale conservation and ecology

Statistical & computational challenges

Next Steps:

- Decision Support Tool (Tom Auer)
- Distribute data products
- Year-by-year analysis & Trends
- Additional data – NDVI, NDWI, …

Research Opportunities:

- Quantify & control bias
- Scale – Fine & Large

References

Fink et al. 2014. Crowdsourcing meets ecology: hemisphere-wide spatiotemporal species distribution models. AI Magazine 35:19–30.

Fink et al. 2010. Spatiotemporal exploratory models for large-scale survey data. Ecological Applications 20:2131–2147.

Fleskes et al. 2007 Pintail and mallard survival in California relative to habitat, abundance, and hunting. Journal of Wildlife Management 71:2238–2248.

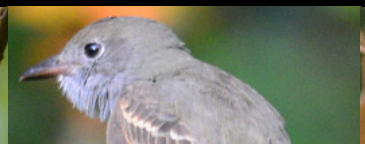
Johnston et al. 2015, Abundance models improve spatial and temporal prioritization of conservation resources. Ecological Applications, 25: 1749–1756. doi:10.1890/14-1826.1

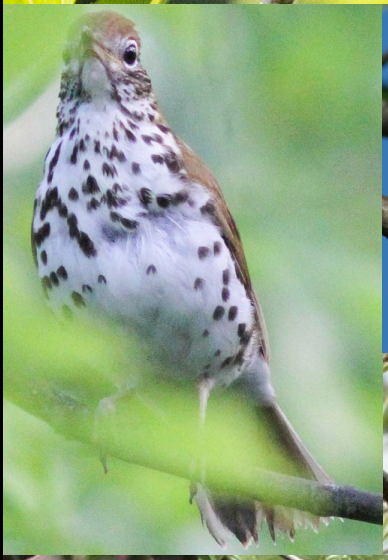
North American Bird Conservation Initiative. 2016. *The State of North America's Birds 2016*. Environment and Climate Change Canada: Ottawa, Ontario. 8 pages. www.stateofthebirds.org

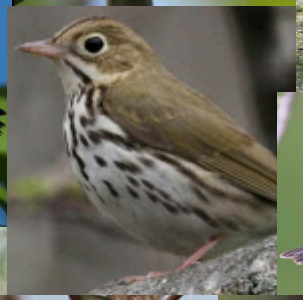
APPENDICES

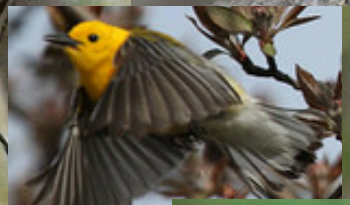
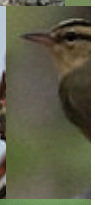
Identifying Important Regions and Seasons Across Species



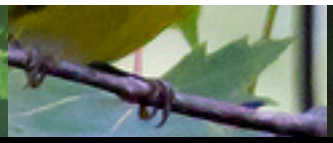
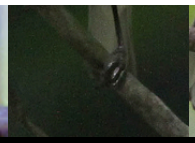
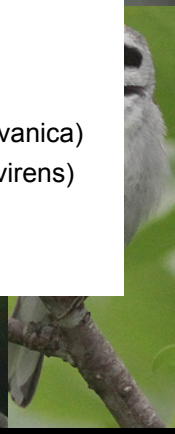







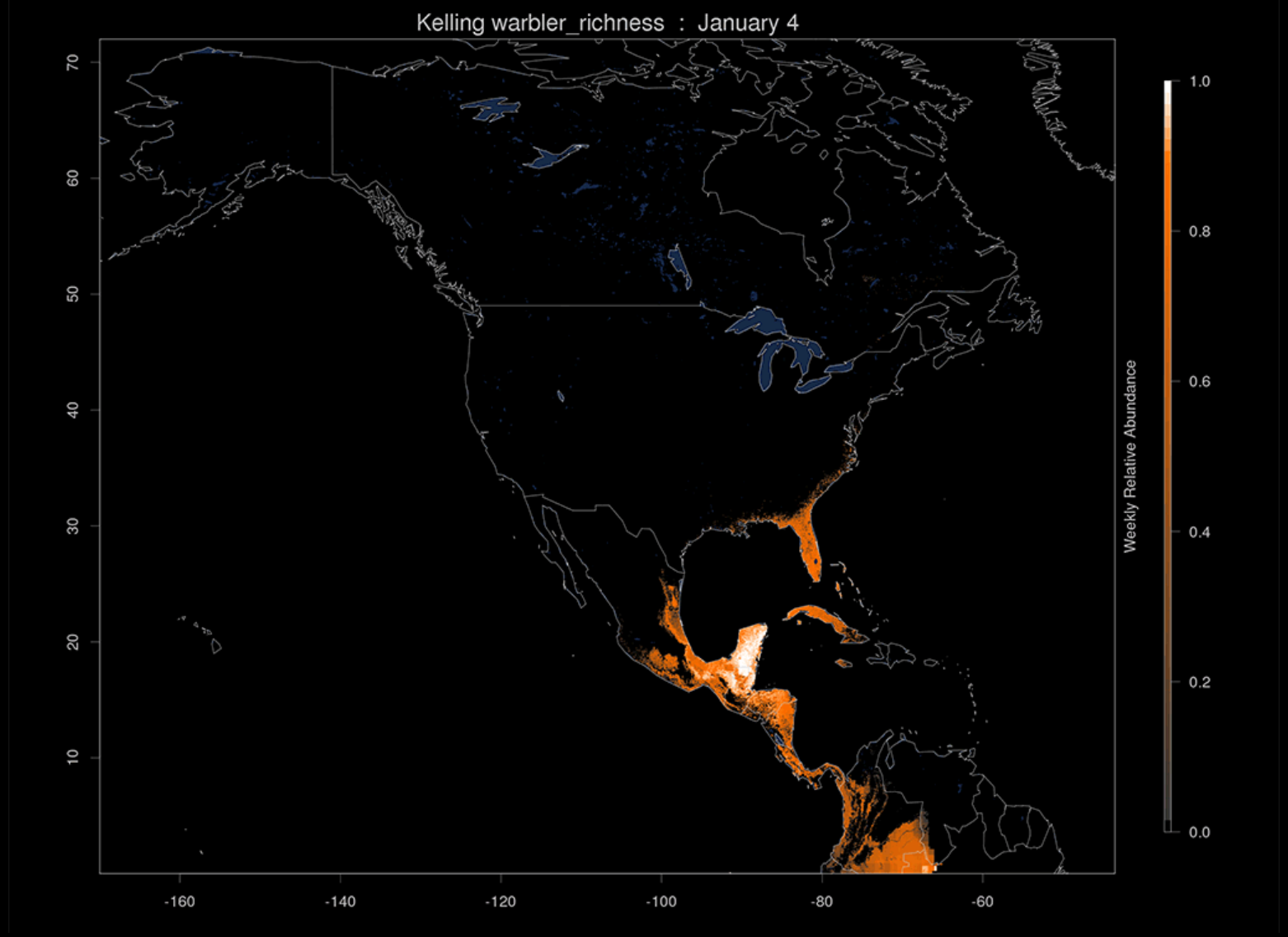


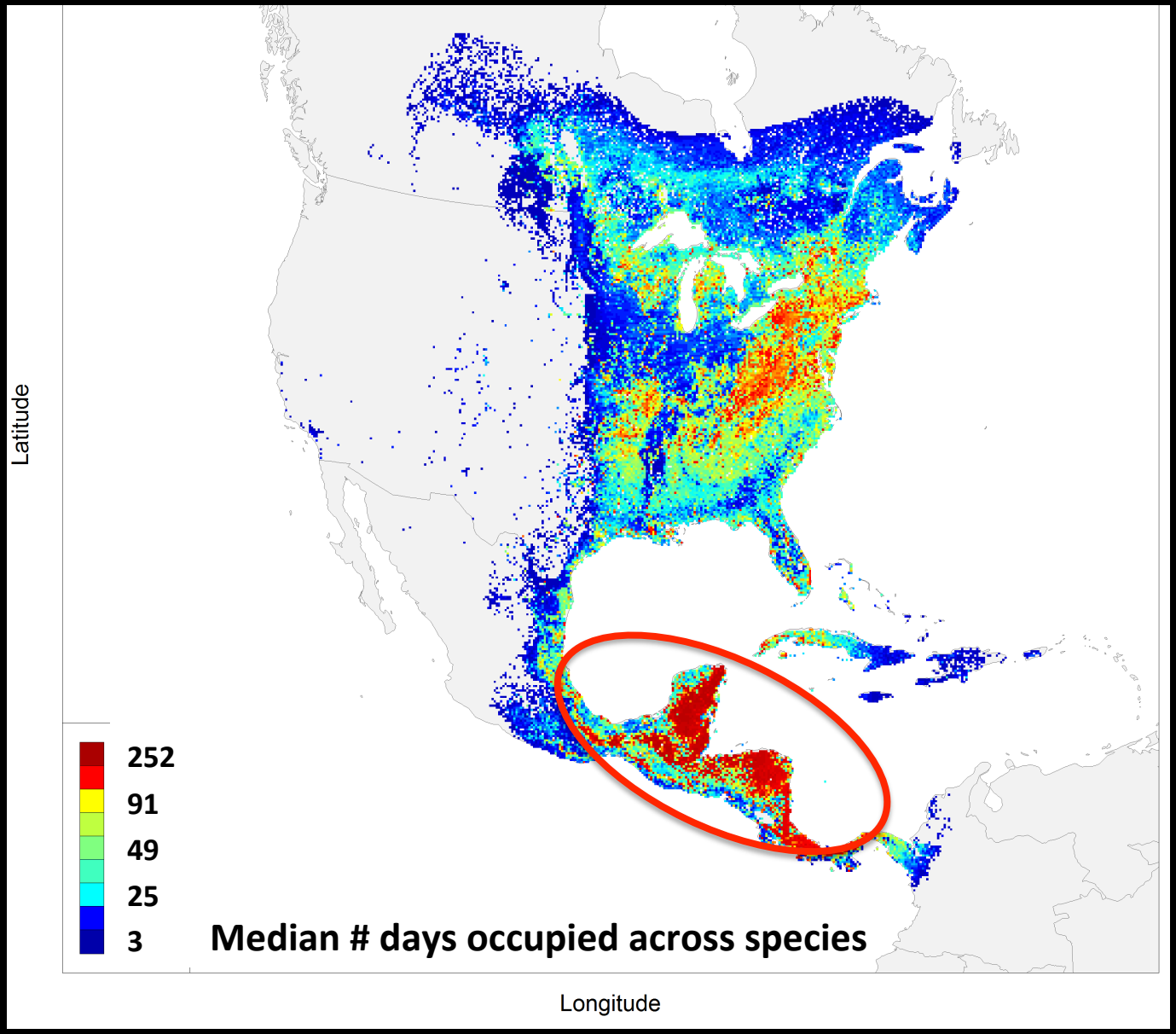
Species: Eastern North American Birds

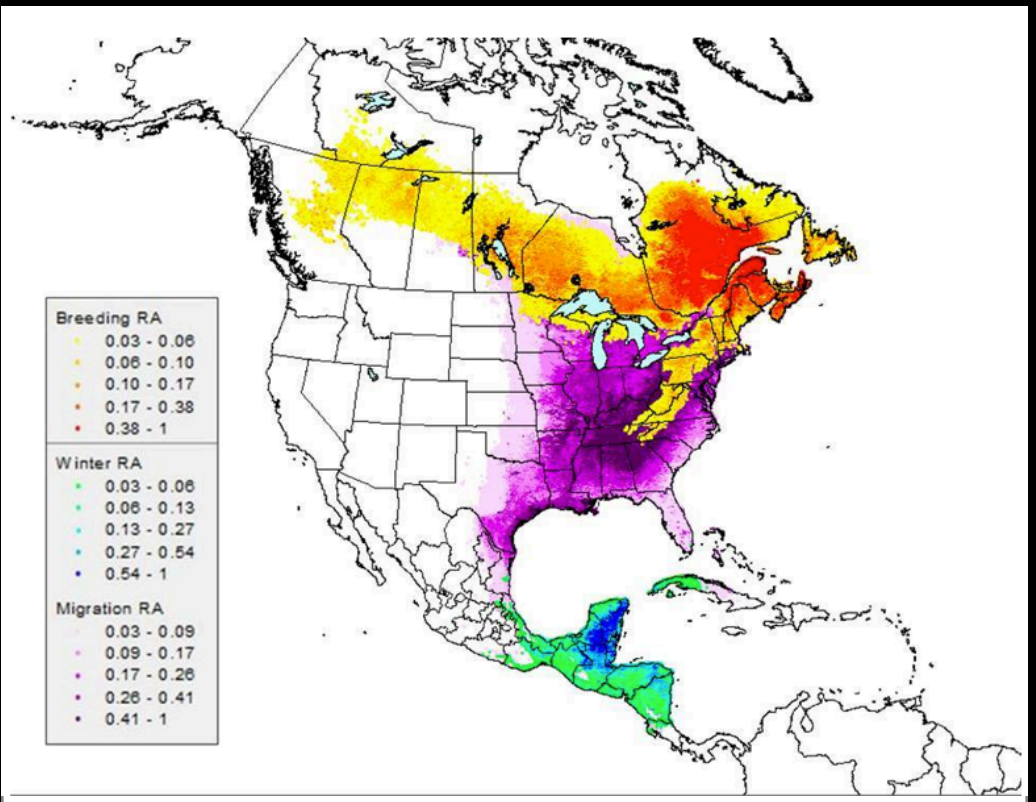
1. Yellow-bellied Flycatcher (Empidonax flaviventris)
2. Acadian Flycatcher (Empidonax virescens)
3. Great Crested Flycatcher (Myiarchus crinitus)
4. Yellow-throated Vireo (Vireo flavifrons)
5. Philadelphia Vireo (Vireo philadelphicus)
6. Wood Thrush (Hylocichla mustelina)
7. Gray Catbird (Dumetella carolinensis)
8. Ovenbird (Seiurus aurocapilla)
9. Worm-eating Warbler (Helmitheros vermivorum)
10. Louisiana Waterthrush (Parkesia motacilla)
11. Golden-winged Warbler (Vermivora chrysoptera)
12. Blue-winged Warbler (Vermivora cyanoptera)
13. Prothonotary Warbler (Protonotaria citrea)
14. Mourning Warbler (Geothlypis philadelphia)
15. Kentucky Warbler (Geothlypis formosa)
16. Hooded Warbler (Setophaga citrina)
17. Magnolia Warbler (Setophaga magnolia)
18. Chestnut-sided Warbler (Setophaga pensylvanica)
19. Black-throated Green Warbler (Setophaga virens)
20. Indigo Bunting (Passerina cyanea)

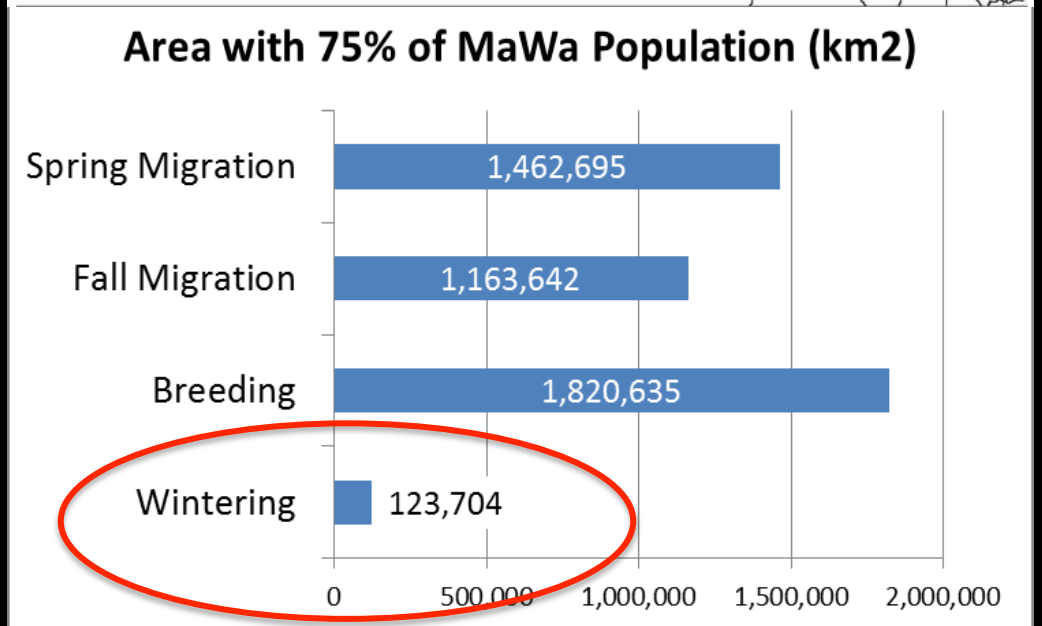
Species Richness = Sum of species' occurrence



Use-days for Broad-scale ST Prioritization




Breeding RA
0.03 - 0.06
0.06 - 0.10
0.10 - 0.17
0.17 - 0.38
0.38 - 1
Winter RA
0.03 - 0.06
0.06 - 0.13
0.13 - 0.27
0.27 - 0.54
0.54 - 1
Migration RA
0.03 - 0.09
0.09 - 0.17
0.17 - 0.26
0.26 - 0.41
0.41 - 1

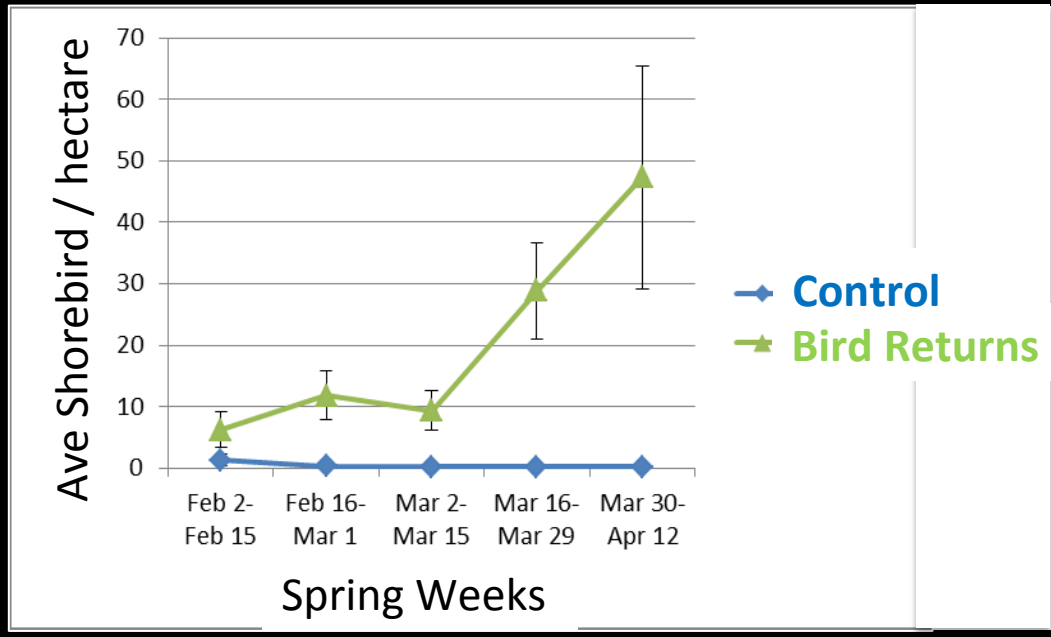

Area with 75% of MaWa Population (km2)
Spring Migration
1,462,695
Fall Migration
1,163,642
Breeding
1,820,635
Wintering
123,704
0
500,000
1,000,000
1,500,000
2,000,000

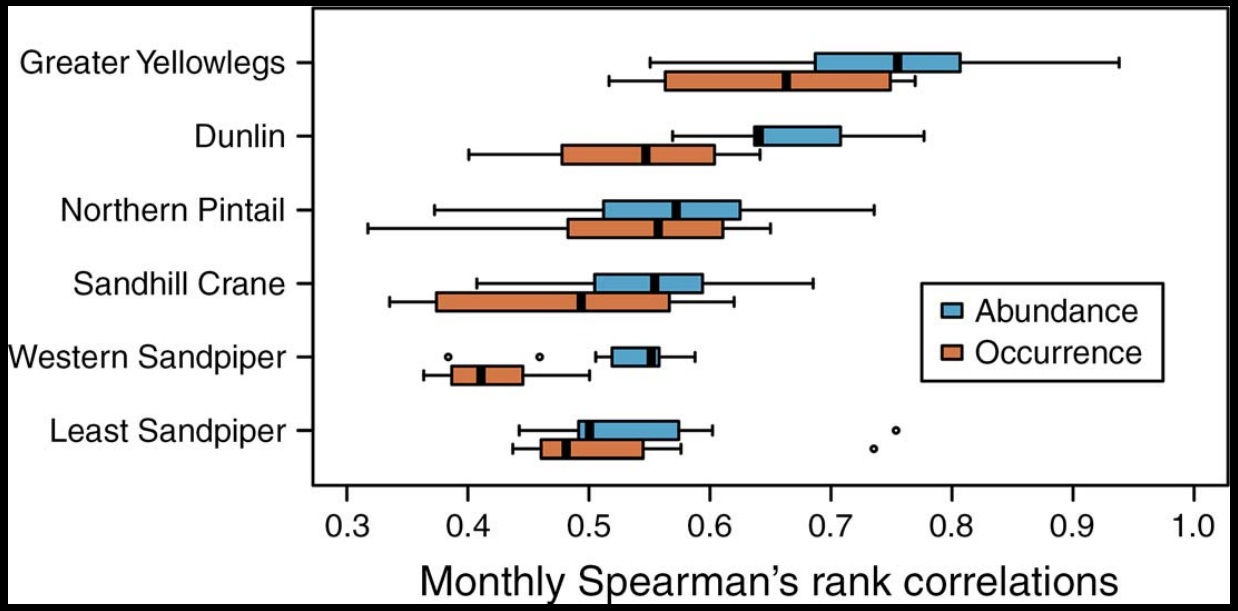
Bird Returns Outcomes

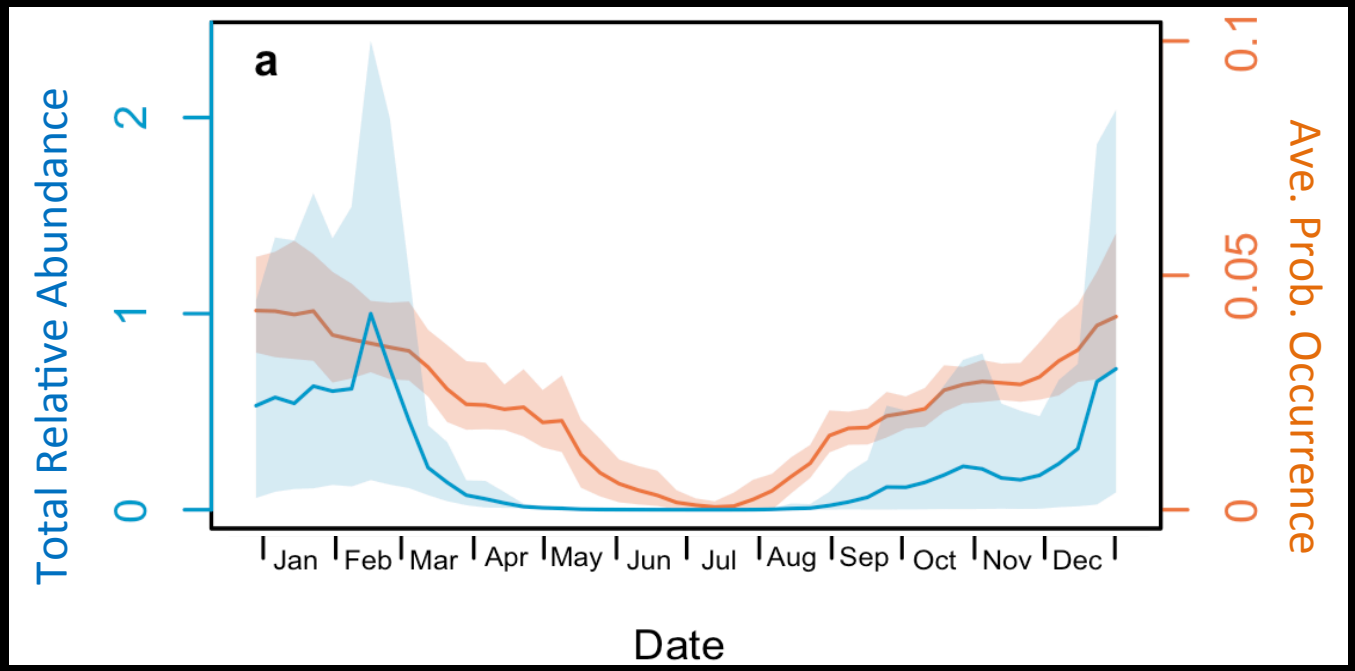
Shorebird monitoring
Richness > 2 times
Densities >> control

Cost Effectiveness
$ Dynamic << $ permanent

Habitat Provided
36,000 acres since 2014




Greater Yellowlegs
Dunlin
Northern Pintail
Sandhill Crane
Western Sandpiper
Least Sandpiper
Abundance
Occurrence
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Monthly Spearman's rank correlations


a
Total Relative Abundance
0
1
2
Ave. Prob. Occurrence
0
0.05
0.1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date

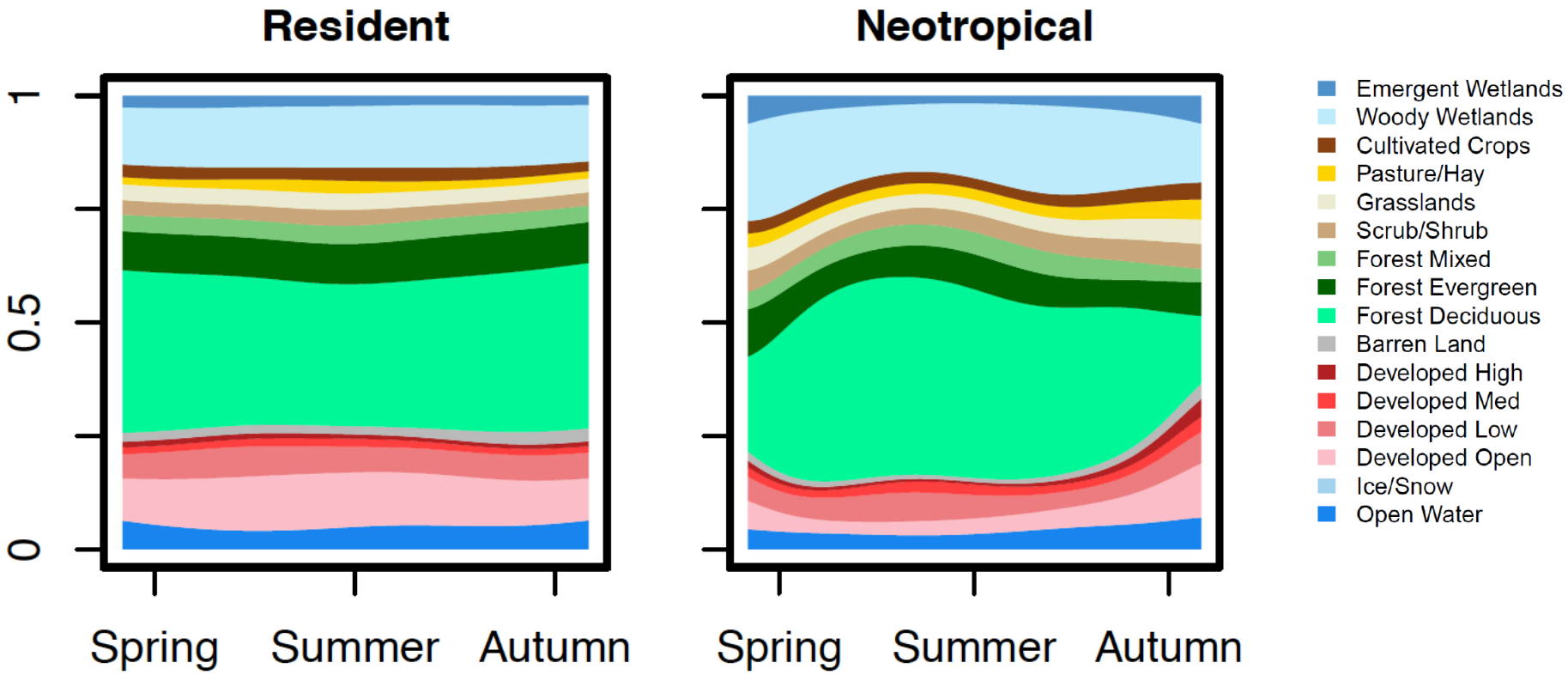
Forest Breeding Birds

Neotropical Migrants

- Scarlet Tanager
- Wood Thrush
- Red-eyed Vireo
- Ovenbird
- Black-and-white Warbler
- Orchard Oriole
- Eastern Wood-Pewee
- Hooded Warbler
- Acadian Flycatcher
- Yellow-Throated Warbler
- Veery
- Northern Parula
- Prairie Warbler
- Chestnut-sided Warbler
- Prothonotary Warbler
- American Redstart
- Yellow-throated Vireo
- Yellow-billed Cuckoo
- Rose-breasted Grosbeak
- Indigo Bunting

Residents

- White-breasted Nuthatch
- Wild Turkey
- Pileated Woodpecker
- Brown-headed Nuthatch
- Tufted Titmouse
- Downy Woodpecker
- Red-bellied Woodpecker
- Northern Cardinal
- Hairy Woodpecker


Resident
Neotropical
1
0.5
0
Spring
Summer
Autumn
Spring
Summer
Autumn
Emergent Wetlands
Woody Wetlands
Cultivated Crops
Pasture/Hay
Grasslands
Scrub/Shrub
Forest Mixed
Forest Evergreen
Forest Deciduous
Barren Land
Developed High
Developed Med
Developed Low
Developed Open
Ice/Snow
Open Water